Brain Dysfunction detection System using Deep Neural Network

Research proposal

Submitted to Symbiosis International (Deemed University)

For

DOCTOR OF PHILOSOPHY
(Faculty of Engineering)

Milind Ashok Natu
(PRN:19079001078)

Under the Guidance of

Dr. Mrinal R. Bachute, Supervisor

Associate Professor, Electronics and Telecommunication Engineering Department.
Symbiosis Institute of Technology
Symbiosis International (Deemed University), Pune

SYMBIOSIS INTERNATIONAL (DEEMED UNIVERSITY), Pune-412115

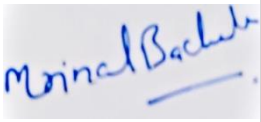
2020

SYMBIOSIS INTERNATIONAL (DEEMED UNIVERSITY)

CERTIFICATE

Research Proposal entitled **"Brain Dysfunction detection System using Deep Neural Network"** being submitted by **Mr**. **Milind Ashok Natu (PRN 19079001078)** to the Symbiosis International (Deemed University), Pune for the registration of Ph.D. Degree under the Faculty of Engineering has been prepared as per the guidelines given Symbiosis Centre for Research and Innovation

Signed by Research Student
Milind Ashok Natu
(PRN:19079001078)



Signed by Research Supervisor
Dr. Mrinal R. Bachute
Associate Professor, Electronics and Telecommunication Engg. Department
Symbiosis Institute of Technology
Symbiosis International (Deemed University), Pune

Signed by Research Co-Supervisor
Name and Designation

Date: 11/01/2021

Place: Pune

1. Introduction:

Electroencephalogram records the activity of internal neurons in the brain and presents in the form potentials from a huge number of neurons. It has some advantages as compared to the other methods: such as it has high temporal resolution (EEG is a particularly valuable tool to neuroscientists, because it is sensitive to **millisecond** changes in neural processing. This property, known as **temporal resolution**). In earlier days EEG signals were analyzed visually, using strip charts. It is very difficult and usually requires large time. Also, manually analyzing these EEG trace shall many times fails and could not expose or extract the underline features within the EEG which may contain significant information. On the other hand, EEG is a low-cost technique which can be used for long-term diagnosis purpose. Therefore, EEG is the mostly used tool for the diagnosis of brain malfunctions.

1.1 Background/Rationale

In recent years, Epilepsy or Epileptic seizure is a common neurological problem or disorder which may affect millions of people. It occurs suddenly or randomly without any prior mark which may suddenly turn in to the death of the patient. Accurate forecasting or predication of seizures would help patient to overcome avoid the helplessness and uncertainty caused due to disease. In order to warn or inform the patient, a reliable system which will warn prior to the occurrence of seizure is needed. Epileptic seizures are a condition of seizure which may vary from patient-to-patient. There are various methods used for recording brain signals such as Electroencephalograms, Imaging techniques such as MRI, and Functional magnetic resonance imaging (fMRI) which measures the small changes in blood flow that occur with brain activity) and also by using Magnetoencephalography.

Epilepsy is a brain neuron functioning disorder where in the electrical signaling system of the brain not works properly. After Literature review it is noticed that epileptic seizures affecting around 50 million people across the globe [1], of which in India it is around 10 million. It is very commonly Observed in young children and adults. Its percentage of occurrence is slightly more in males as against in females. It is observed that this disease is not cured to 100% level, but the severity and the extent of disorder can be made under control by proper treatments and other strategies.

Need of Analysis of Signal:

Seizures occurs due to uncoordinated electrical signaling among the neurons or discharge generated by the neurons is uncertain, mainly in cerebral cortex. A person suffering from epilepsy is unable to perform normal routine tasks and experience abnormality in movements, gestures, sensation, behavior and awareness. There are two important indications during seizure, such as Ictal and Interictal state. Entire period or duration of seizure is represented as Ictal state while interval between two ictal is Interictal. To save a person from next seizure and to ensure better treatment, seizure prediction is necessary. There are various methods of feature extraction and classification do exist for seizure detection.

Seizure: Brain consists of neurons and, these neurons either stimulate other neuron cells. Generally, there is a balance in functioning of neurons. But when a seizure came there may be dearth of activity i.e., improper functioning of neurons within the brain.

2. Review of Literature

Reference 1: Hung et al. [1] developed system of seizure prediction which is based on concept of wavelet and theory of chaos. A two level Daubechies-4, WT is used to get optimal band of EEG and then correlation dimension feature computed. This work discovered by certain bandwidth of signal extracted with DWT, and the combination with Chaotic features analysis, it can achieve a higher accuracy of epileptic prediction. Furthermore, the correlation coefficient between two correlation dimensions with different embedding dimensions was proposed as a novel feature for epileptic seizure prediction in this study. The performance of the system resulted with an average prediction rate of 27 minutes with sensitivity 86%.

Reference 2: Staneik et al. [2] proposed a seizure detection algorithm for 0-25 Hz EEG band using discrete Fourier Transform. Spectral and Temporal features of signal can be easily extracted. One of the challenges in this field is the fact that a priori it is not obvious which regions in the brain have to be studied in order to reveal predictive information. In this work, the mean coherence, a bivariate symmetric measure for the strength of interactions between two brain regions, is estimated in a time-resolved fashion (moving-window approach). The phases of the iEEG time series are obtained either with a frequency-adaptive (via the Hilbert transform) or with a frequency-selective approach (e.g., via the wavelet transform). Both approaches were shown to give similar results for a quantitative analysis of phase synchronization from neuronal data as well as in seizure prediction studies. The parameters are obtained for two classes and artificial neural network (ANN) has been used to test. CHB-MIT EEG Dataset is used and 93 % accuracy is stated

Reference 3: Assous & Boashash [3] presented a method in their research paper that considers the problem of phase synchrony and coherence analysis using a modified version of the S-transform, referred to as the Modified S-transform (MST). This is a novel and important time-frequency approach to study the phase coupling between two or more different spatially recorded entities with non-stationary characteristics. This articles presents using phase synchronous and coherence analysis for different scalp location signals. Simultaneous or Synchronized brain activity in both halves of the skull is initially observed in temporal lobe.

Reference 4: Khamis et al. [4] processed noise free scalp EEG data. They investigated spectral power from the left and right side of the scalp locations and calculated differences and termed as spectral moment signatures as one spectral quantity. They investigated spectral power from the left and right side of the scalp locations and calculated differences and termed as spectral moment signatures as one spectral quantity. These moments of power spectral densities have been used as feature. In the results, the researchers expressed sensitivity for the subject specific detection method as 91%.

Reference 5: Alotaiby et al. [5] reported in review article on long term EEG signal, seizure detection method using Spectral energy-based method by contemporary researchers worked on CHB-MIT database had given an accuracy of nearly 84%. This review consists of seizure detection process that can be made on a single- or multi-channel basis. Single-channel seizure detection requires selecting the channel containing the strongest EEG signal collected from the

closest point to the seizure spot. This selection process depends mainly on activity measures evaluated for the different channels instantaneously such as the local variance.

Reference 6: Sheoran & Saini [6] applied two sets of data from Andrzejak, University of Bonn. Wavelet based decomposition filter is developed to extract EEG sub bands coefficient features. Further, statistical distribution is applied to determine the measure to find seizure. The method is applied to test normal and seizure segments. The features extracted from the principal components that are evaluated from the wavelet sub-bands, differentiate between these two states. Further, t-student statistical distribution is applied to determine the measure of distinguishing between different subjects. The method of principal component analysis on wavelet sub-bands can discriminate between ictal & non-ictal subjects with 99.99% pvalue (eye open) and 99.96% p-value (eye closed) using the delta sub-band.

Reference 7: Pravez et al. [7] developed empirical mode decomposition (EMD) method for detection of pre-stage seizures. The pre ictal has been taken 3 minutes prior to seizure onset from dataset from 12 subjects with focal electrodes. The performance of Support Vector Machine (SVM) classifier has a sensitivity of 82%. In this work, authors proposed a technique based on Independent Component Analysis (ICA) for removing artifact, then exploited temporal correlation of the signal by applying EMD decomposition and Discrete Cosine Transformation (DCT) techniques to extract features. These features are used as an input to Least-Squared Support Vector Machine (LS-SVM) for classification of pre-ictal and inter-ictal EEG signals. A major drawback of SVM is its higher computational burden of the constrained optimization programming, however, LS-SVM can solve this problem.

Reference 8: Giri et al. [8] elaborated a work to detect seizure stroke based on EEG using one dimensional convolution neural network. Deceleration of EEG signal occurs due to obstruction of cerebral blood flow. The pre-processing stage EEG recorded with 256 Hz sampling rate was used and power spectral density for every frequency band from 0 Hz to 128Hz are calculated. In this work, one dimensional convolution neural network architecture with various convolution maps and variable kernel size are used to discriminate EEG signal. Several classifiers are used for comparative analysis. The simulation result shows that Naïve Bayes method provides good performance with 200 epochs.

Reference 9: Costa et al. [9] assessed a reliable lead field matrix to solve the Magneto Encephalography/Electroencephalography (M/EEG) source localization problem. The calculations involved are bit Treacy as they involved Matrix Since these parameters are not precisely known, they modify a recent Bayesian algorithm which is used to estimate the brain activity directly from the EEG measurements. Since it is not precisely known, authors modified Bayesian algorithm to estimate the skull conductivity jointly with the brain activity directly from the M/EEG measurements.

Reference 10,11 and 12 are available for Various Online Datasets.
The detail (Link) is given in the references

Reference:13 Robert Janke and et.al [13] proposed the Comparative study for feature extraction methods of EEG signals for emotions detections in various domains. They also commented on the

positions of electrodes on the scalp is also very important factor in order to get the signals. Many methods for feature extraction have been studied and the selection of both appropriate features and electrode locations is usually based on neuro-scientific findings. Their suitability for emotion recognition, however, has been tested using a small amount of distinct feature sets and on different, usually small data sets. A major limitation is that no systematic comparison of features exists.

Reference 14: C. Tang and et.al [14] suggested Moving Average Smoothing Technique on Statistical Data and then applying Classifier and training the dataset and it was fond that accuracy has increased from 51.27% to 84% on 80/20 classification. Specifically, authors extract six statistical features from raw EEG signals and apply a simple yet cost-effective feature smoothing method to improve the recognition accuracy.

Reference 15: Yuan pin lin and et.al [15] proposed Support Vector Machine method is proposed as classifier to classify four different states of emotions such as Joy, anger, sadness and Pleasure on Existing Dataset and Accuracy about 82.29% is achieved. In this work, authors have focused on the approach for recognizing music-induced emotional responses from brain activity. A comparative study was conducted to testify the feasibility of using hierarchical binary classifiers to improve the classification performance as compared with nonhierarchical schemes.

Reference 16: M. Akin [16] in his work Compared the Process of Wavelet Transform (WT) and FFT (Fast Fourier Transform) for the analysis of EEG signal for analyzing the performance, and in the conclusion, he found that Wavelet transform is much better than FFT analysis for detecting Brain Diseases. Basically, his Work study focuses on the performance analysis of both the methods.

Reference 17: X. Wu, and et.al [17] in their research paper proposed the method of classification for multimodal EEG signals and able to achieve classification accuracy for SEED dataset up to 95% and for SEED-V up to 84%. Multichannel EEG simultaneously measures coordinated brain activities at multiple sites on the scalp at millisecond temporal resolution, which makes it valuable for cognitive and neural engineering studies and for clinical applications. However, the analysis of EEG remains challenging because the volume-conducted EEG suffers from a low spatial resolution.

Reference 18: Peiyang Li [18], and et.al in their Research paper explained the use of power spectral density analysis plays a major role for different emotion recognition and able to classify up to 67 to 70% on DEEP dataset. In this work, both information propagation patterns and activation difference in the brain were fused to improve the performance of emotional recognition.

Reference 19: Wei Wu and et.al [19], in their Research paper they explained the use of common spatial patterns (CSP) filtering technique in multichannel EEG signals the proposed framework in this paper will resolve the issue of overfitting in CSP. Specifically, probabilistic CSP (P-CSP) is proposed as a generic EEG spatio-temporal modeling framework that subsumes the CSP and regularized CSP algorithms. The proposed framework enables us to resolve the overfitting issue of CSP in a principled manner.

Reference 23: Hisham Daoud and et.al [23] in their paper proposed CNN (Convolutional Neural Network) methods of features extraction and compared the results of accuracy. The proposed approach takes advantage of the convolutional neural network in extracting the significant spatial features from different scalp positions and the recurrent neural network in expecting the incidence of seizures earlier than the current methods. A semi-supervised approach based on transfer learning technique is introduced to improve the optimization problem. A channel selection algorithm is proposed to select the most relevant EEG channels which makes the proposed system good candidate for real-time usage. An effective test method is utilized to ensure robustness.

Reference 24: Tahir Ahmad and et.al [24] in their research paper used heuristic algorithm for iteration and performed the analysis in time domain and concluded that Seizure activity starts at t=3 and end till up to t=8. In this work, authors first briefly introduce Heuristic algorithm of Fixed Point Iteration. Then, Heuristic algorithm of Fixed point iteration is applied to cluster of EEG signal of patients during epileptic seizure. Optimal number of cluster is obtained with using two types of cluster validity measure. Finally, the result of the clustering is shown using flatting EEG signal and programing by Matlab software

Reference 25: ALI YADOLLAHPOUR1 and et.al, in their research paper suggested a Heuristic Algorithm approach of fixed-point iteration method which is time domain analysis and were able to detect the appearance of Seizure at t=3 and ends at t=7. The authors have presented the study reviews the most important and recent methods for seizure prediction.

Reference 26: Sun-Hee Kim and et.al, in their research article proposed the ARMA Prediction model which is type of Linear regression model type, they are able to achieve accuracy up to 80-85% by changing certain parameters. In this work, the authors propose a coercively adjusted auto-regression (CA-AR) method that forecasts future values from a multivariable epilepsy EEG time series. In this work they use the technique of random coefficients, which forcefully adjusts the coefficients with −1 and 1.

Reference 27: Khansa Rasheed and et.al in their Review Paper Compared different methods of classification used in Supervised Machine learning algorithms such as SVM kernel, Linear Regression, Basien tree, Random forest. by doing so they compared the performance of every algorithm and found that every algorithm has different pros and cons but out of this SVM kernel method gives more accurate results and great precision among the all

3. Research Gaps:

Sr. No	Paper Title	Method Used	Accuracy/Result	Paper Refence No.
2010				

1	Implementation of VLSI architecture for Epileptic Seizure Prediction using System based on Wavelet and Chaos Theory	Seizure prediction system is developed using wavelet transform and chaos theory also implemented VLSI-FPGA based algorithm for System Architecture	A two level Daubechies-4, WT is used to get optimal band of EEG and then correlation dimension feature computed. The performance of the system resulted with an average prediction rate of 27 minutes with sensitivity 87%.	1
2011				
2	Identification of Pre-seizure states in epilepsy: A data-driven approach for multichannel EEG recordings	proposed a seizure detection algorithm for 0-25 Hz EEG band using discrete Fourier Transform (DFT). Various spectrum features are extracted from time domain data of signal.	The parameters of spectrum are obtained for two classes and an artificial neural network (ANN) has been used to test (CHB-MIT). EEG time series data and 93 % accuracy are stated.	2
2012				
3	Evaluation of the modified S-transform for time frequency synchrony analysis and source localization	In this paper author presented a study of association parameters used between different scalp location signals. using phase synchrony and coherence analysis	Phase synchronization is found to be very sensitive indicator of seizure pre cursor. Modified S-Transform method is Used	3
2013				
4	Frequency and moment signatures: A method for automated seizure detection from scalp eeg	They investigated spectral power from the left and right side of the scalp locations and calculated differences and termed as spectral moment signatures as one spectral quantity. These moments of power spectral densities have been used as feature.	In the results, the researchers expressed sensitivity for the subject specific detection metho as 91%. DWT is Used	4
5	Probabilistic Common Spatial Patterns for Multichannel EEG Analysis	Common Spatial patterns (CSP) is Well known Approach for multichannel EEG signal analysis	In the result accuracy up to 91% achieved with Probabilistic CSF	19
2014				
6	Epileptic Seizure Detection using PCA on wavelet sub-bands	Data from Andrzejak, University of Bonn. Wavelet based decomposition filter is developed to extract EEG sub bands coefficient features. Further, statistical distribution is applied to determine the measure to find seizure.	Features are extracted using Wavelets and PCA is used as Classifier	6

		The method is applied to test normal and seizure segments.		
7	Seizure Prediction Methods: A Review of the Current epilepsy Predicting and learning Techniques	A review Paper which will compare different techniques of Epilepsy prediction and analysis using various techniques such s Time domain analysis, Frequency domain analysis etc	Different methods in frequency domain and time domain re compared	26
8	Revies paper on eeg A survey on seizure detection and prediction machine learning algorithms:	Reported in review article on long term EEG signal, seizure detection method using Spectral energy-based method by contemporary researchers worked on CHB-MIT database	Achieved an accuracy of nearly 84%.	5
2015				
9	Detection of Pre-stage of epileptic seizure by exploiting temporal correlation of EMD Decomposed EEG Signals	Developed empirical mode decomposition (EMD) method for detection of pre-stage seizures. The pre ictal has been taken 3 minutes prior to seizure onset from dataset from 12 subjects with focal electrodes.	The performance of Support Vector Machine (SVM) classifier has a sensitivity of 82%.	7
2016				
10	Ischemic Stroke Identification Based on EEG and EOG using 1D Convolutional Neural Network and Batch Normalization	Power spectral density for every frequency band from 0 Hz to 128Hz are calculated. In this work, one dimensional convolution neural network architecture with various convolution maps and variable kernel size are used to discriminate EEG and EOG. Several classifiers are used for comparative analysis.	In this paper 1D CNN is used and by increasing the EPOCHS the Accuracy of Classification increases to great extent. The simulation result shows that Naïve Bayes method provides good performance with around 200 epochs.	8
02017				
11	Emotion Recognition via Fast and Robust Feature Smoothing using EEG-Based	Multimodal Features with Different Classifiers such as SVM, Neive Bays, CNN, SVM with Kernel were used and their classification accuracy is compared, DEAP Dataset was used	It is Stated in the paper that among all the Classifier SVM kernel has the Highest Classification Accuracy which was around 82.3% as against the other methods whose accuracy varies from 57% to 74%	14

2019				
12	Emotion recognition by for EEG signals using functional connectivity network and local activations	Multi-Modality Feature Extraction Algorithm for Emotion detection using Brain network and Phase Locking Value (PLV), MAHNOB-HCI, DEAP Dataset and Recorded Signals for Analysis, SVM and ELM classifiers are used	Classification Accuracy is improved by changing Sampling Rate for every dataset is observed and Overall Accuracy is Improved	18
13	Investigating EEG-Based Functional Connectivity Patterns for Multimodal Emotion Recognition	Three Channel EEG Connectivity features. Feature Extraction Algorithm for Emotion Detection (Disgust, Fear, sad, Happy and Neutral). Movie Clips used as Stimuli. (SEED, SEED-V) Dataset is used, LDS, mRAR classifiers are used	Classification Accuracy achieved up to 74.05% against the single channel which was 69.05%	17
14	Emotion Recognition Using Regularized Graph Neural Networks (RGNN)	In this Paper author has used RGNN based method for emotion recognition on SEED and SEED-IV dataset	Classification Accuracy using SVM is Achieved up to 85%	22
15	Efficient Epileptic Seizure Prediction based on Deep Learning	Four Deep Learning Models are used to extract the features and increase the classification accuracy. Uses Convolutional Neural Network	Classification Accuracy is achieved up to 84% to 95%	23
16	Detection of Epilepsy from EEG Signal during Seizure Using Heuristic Algorithm of Fixed-Point Iterations	Heuristic Algorithm of Fixed-Point Iteration is used for diagnosis of Dynamics in EEG signal	It's a time domain analysis and shows that Seizure activity starts at t=3 and remains till t=7 and start dyeing at t=8	25
17	Use of Auto Regression Model for Forecasting the Epilepsy in EEG signal	In this paper ARMA model (Linear Prediction method) is used which is time domain analysis of signals	It is time domain analysis and Auto regressive model is used for forecasting epilepsy seizures	26
2020				
18	Machine Learning for Predicting Epileptic Seizures Using EEG Signals: A Review	In this Review Paper Different Techniques of Epilepsy prediction are compared and performances are analyzed	Different techniques of Classification and Comparison are compared and analyzed	27

19	Epileptic Seizures Prediction Using Deep Learning Techniques	Used Convolutional Neural Network on CHBMIT dataset	Using CNN technique achieved accuracy up to 92.75%	28

4. Research Questions

1. What are the Various Parameters associated with Seizures spikes in EEG spectrum (Like frequency, Amplitude, Power, etc)?
2. What type of Dataset is going to refer and how are they labelled?
3. What are Different methods of Signal classification (Classifier algorithm)?
4. What is the level of Accuracy, and error will be predicted?

5. Statement of the Problem:

Design and develop an Early warning or messaging system and Identify Type of Epileptic Seizure using Deep Neural Network from EEG spectrum Signal.

6. Objectives of the Study:

1. To select the optimal length of EEG epoch for analysis since it is non stationary.
2. To proposed a strategy for the optimal selection of channels essential for accurate epilepsy detection.
3. Develop a customized deep learning methodology which can learns most prominent features and process from multi-channel EEG data automatically to detect epilepsy with improved accuracy.
4. Validate the performance of the proposed approach with qualitative analysis and compare it with existing state of art methods

7. Scope and Limitations:

Scope: Till now several methods have been proposed, yet there is a scope to propose an efficient, fast prediction and detection method

1. To present a fully automatic warning system for the detection of seizure in EEG signal.
2. Work can be extended to Detection and Analysis of Emotions, Motor Imaginary Work and so on
3. Features from time-domain, spectral domain and transform domain can be used and extracted, and later the deep networks are used to detect and classify the epilepsy in the signals.
4. Efficiency of the System can be increased by making use of DNN network to Accurately predict the type of Seizure.

Limitations: The difficulties lie in the EEG analysis are as following

1. Removal of non-brain EEG activity including eye blinks, eye movement, electromyographic (EMG), electrocardiographic (ECG) signals and power line noise from the EEG signal without affecting EEG data.
2. The selection of optimal length of EEG epoch for analysis since it is non stationary.
3. The use of single channel has limitation of providing very less information and many channels are not efficient due to increased complexity in computation of features. Hence selection of optimal channels is essential for computation of features.
4. Feature values vary with different activities of the brain. So selection and computation of features for detecting seizure onset zone and identification of non-seizure, pre seizure and seizure from the EEG data is difficult.

8. Research Gaps

From the above literature survey few research gaps were observed

- The use of single channel has limitation of providing very less information and many channels are not efficient due to increased complexity in computation of features. Hence selection of optimal channels is essential for computation of features.
- Class imbalance is also a serious problem in Machine Learning Classifiers.
- Most of the research work is done on homogeneous data.
- To design a system, one must use a large database.
- Advance Machine learning classifiers are providing more accuracy on limited set of homogeneous data and patient specific data.
- After detecting the seizure, it is also important to detect the type of seizure which facilitates the patient with the required medication.

9. Methodology Tools and Techniques

The schematic of proposed method is shown in Fig.1. The proposed method includes

1. Collecting the data set
2. Dataset Pre-processing
3. Channel selection and Detection of Epilepsy
4. Classification of Epilepsy

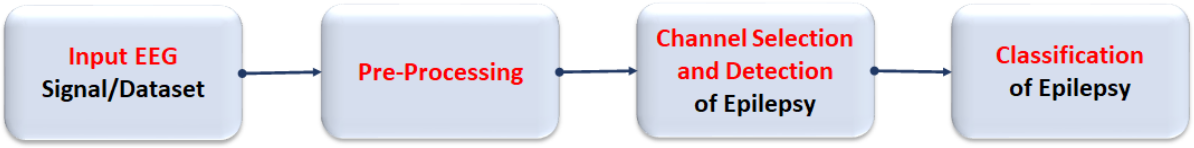


Figure 1: Block diagram for Epileptic Seizure Detection and Classification

A. Input EEG

Many EEG signals repositories are publicly available for research. So, in this work we use such datasets for detection and classification of Epilepsy seizures. Generally, the dataset from different Universities consists of brain signals in five different classes:

- EEG signals from healthy patient with eyes opened and closed condition.
- EEG signals from the epileptic patient at seizure free intervals with eyes opened and closed condition and
- EEG signal from the epileptic patient during the seizure occurrence.

B. Pre-Processing

In the detection of brain activity, electroencephalogram (EEG) plays a significant role. However, the recorded electrical activity of the brain always includes artifacts and affects the EEG signal analysis. Therefore, methods to extract clean EEG data are necessary. In the EEG signal, artifacts may arise due to the impairments in the measuring instrument, human subjects, faculty electrodes, noise and line impedance [15]. In EEG signals, eye movements, eye blinks, heart activity and muscle activity are some major type of physiological artifacts. Different pre-processing techniques like Filtering, EMD, Wavelet based, Independent Component Analysis, and Blind Source Separation techniques are available to remove the artifacts from EEG signals. This process may be performed using hybrid techniques also.

C. Channel Selection and Detection

EEG data is usually recorded from more than 100 locations across the brain, so efficient channel selection algorithms are of great importance to identify channels containing relevant information. The main purpose of applying channel selection is to improve classification accuracy by reducing over-fitting. Different channel selection algorithms such as filtering, wrapper, Common spatial pattern method, Rayleigh coefficient based genetic algorithm and hybrid methods are already available for extracting optimal channel subsets based on a pre-defined criterion for specific applications. In this work, it is intended to propose a Deep Network Model DNN to select the channels which contain information useful for the detection of epilepsy with improved accuracy.

D. Detection and Classification

After detecting the epilepsy, epilepsy can be classified into Focal and Generalized using a Machine Learning/ Deep Learning classifier.

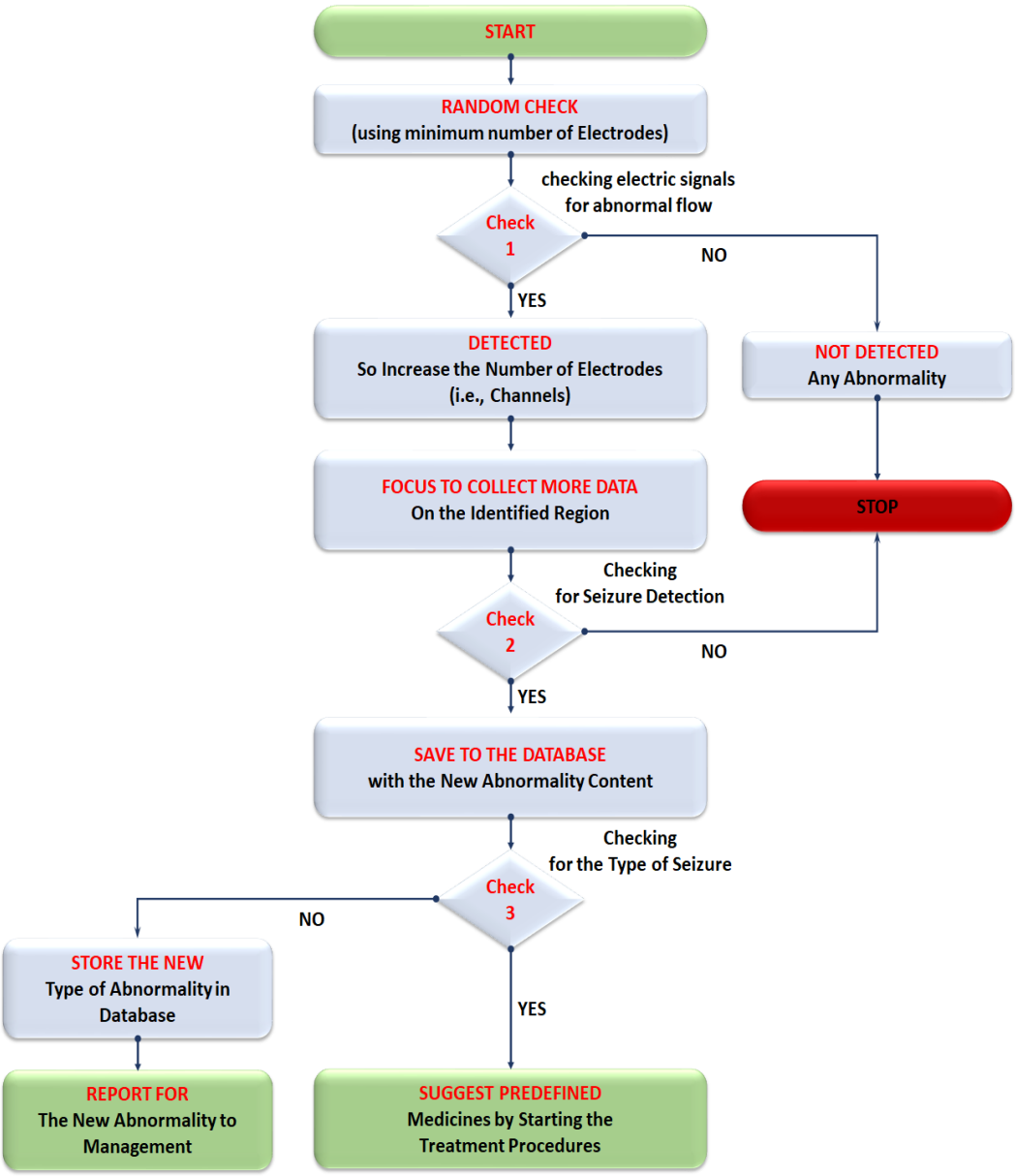


Figure 2: Flow-Chart for the Deep Learning Method for the Proposed Novel for Epileptic Seizure Detection Mechanism

10.Expected Outcome of the research work

The following are some of the expected outcomes of the research

i. A simple and most effective approach of epilepsy detection will be developed
ii. Unlike earlier algorithms which produce high false positive when tested with real hospital environmental condition, this approach provides a pathway to minimize these false positives.
iii. This approach may provide high specificity and sensitivity with multiple types of seizures.

11. Schedule of Proposed Work

Schedule of research will be as per given steps

Phase	Description	Time Frame
I	Literature Survey	6 months
II	Problem Statement	1 month
III	Finalization of Parameters	3 months
IV	Mathematical Modeling	4 months
V	Design & Theoretical Analysis	4 months
VI	Experiment by Taking Selected Parameter	4 months
VII	Study of Experimental Results & Validation.	4 months
VIII	Publication in selected referred journal	4 months
IX	Thesis Writing & Submission	4 months

12.References

[1] Hung, SH, Chao, CF, Wang, SK & Lin, BS 2010, 'VLSI implementation for epileptic seizure prediction system based on wavelet and chaos theory', TENCON, IEEE, pp. 364-368.

[2] Hinnerk Feldwisch-Drentrup, Matthäus Staniek, Andreas Schulze-Bonhage, Jens Timmer, Henning Dickten, Christian E. Elger7, Björn Schelter and Klaus Lehnertz , 'Identification of Pre-seizure states in epilepsy: A data-driven approach for multichannel EEG recordings', Frontiers in Computational Neurosciences, 7 July 2011, Volume 5 Article 32,pp. 1-9.

[3] Said Assous and Boualem Boashash, 'Evaluation of the modified S-transform for time-frequency synchrony analysis and source synchronization', EURASIP, Journal of signal processing, Springer, vol. 2012, no. 49, pp. 1-18.

[4] Heba Khamis, Armin Mohamed, Steve Simpson, ‘Frequency–moment signatures: A method for automated seizure
detection from scalp EEG’, Journal of Clinical Neurophysiology, vol. 124, no. 12, pp. 2317-2328.

[5] Turkey N Alotaiby, Saleh A Alshebeili, Tariq Alshawi, "EEG seizure detection and prediction algorithms: a survey ", Journal on Advanced in Signal Processing as EURASIP, Springer Open Journal, vol. 2014, no. 183, pp.1-21.

[6] Sheoran, P & Saini, JS 2014, ‘Epileptic seizure detection using PCA on wavelet sub bands’, IEEE, pp. 527-532.

[7] Mohammad Zavid Parvez, Manoranjan Paul, and Michael Antolovich, ‘Detection of Pre-stage of Epileptic Seizure by Exploiting Temporal Correlation of EMD Decomposed EEG Signals’, Journal of Medical and Bioengineering, vol. 4, no. 2, pp.110-116.

[8] Giri, EP, Fanany, MI & Arymurthy, AM 2016, 'Ischemic Stroke Identification Based on EEG and EOG using 1D Convolutional Neural Network and Batch Normalization', „arVix.org“, pp.1-13

[9] Costa, F, Batatia, H, Oberlin, T &Tourneret, JY 2017, 'Skull Conductivity Estimation for EEG Source Localization', IEEE Signal Processing Letters, vol. 24, no. 4, pp. 422-426

[10] https://github.com/meagmohit/EEG-Datasets

[11] https://www.isip.piconepress.com/projects/tuh_eeg/html/downloads.shtml

[12] http://epileptologie-bonn.de/cms/upload/workgroup/lehnertz/eegdata.html

[13] Robert Jenke, Angelika Peer, and Martin Buss, “Feature extraction and selection for emotion recognition from EEG,” IEEE Transactions on Affective Computing, vol. 5, no. 3, pp. 327–339, 2014.

[14] Cheng Tang, Di Wang, Ah-Hwee Tan, and Chunyan Miao, “EEG-based Emotion recognition via fast and robust feature smoothing,” in International Conference on Brain Informatics. Springer, 2017, pp. 83–92.

[15] Yuan-Pin Lin, Chi-Hong Wang, and et.al., "EEG-based emotion recognition in music listening”, IEEE Transactions on Biomedical Engineering, vol. 57, no. 7, pp. 1798–1806, 2010.

[16] M. Akin, “Comparison of wavelet transform and FFT Methods in the Analysis of EEG Signals,” Journal of Medical Systems, Vol. 26, no. 3, pp. 241–247, 2002.

[17] Xun Wu, Wei-Long Zheng, “Investigating EEG-Based Functional Connectivity Patterns for Multimodal Emotion Recognition,” in the 9th International IEEE Conference on Neural Engineering. IEEE, 2019, pp. 235–238.

[18] P. Li, Huan Liu, and et.al, 'EEG based emotion recognition by functional connectivity network and local activations', IEEE Transactions on Biomedical Engineering, Vol. 66, no. 10, pp. 2869–2881, 2019.

[19] Wei Wu, Zhe Chen, Xiaorong Gao, "Probabilistic Common Spatial Patterns for Multichannel EEG Analysis," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 37, no. 3, pp. 639–653, 2014.

[20] Wei Wu, Srikantan Nagarajan, and Zhe Chen, "Bayesian machine learning: EEG/MEG signal processing measurements,", IEEE Signal Processing Magazine, vol. 33, no. 1, pp. 14–36, 2015.

[21] Feifei Qi, Yuanqing Li, and Wei Wu, "A novel algorithm for spatio temporal filtering and classification of Single trial eeg signals", IEEE transactions on neural networks and learning systems, vol. 26, no. 12, pp. 3070–3082, 2015.

[22] Peixiang Zhong, Di Wang, and Chunyan Miao, "EEG-Based Emotion Recognition Using Regularized Graph Neural Networks", JOURNAL OF LATEX CLASS FILES, VOL. 14, NO. 8, AUGUST 2019

[23] Hisham Daoud, Member, IEEE, Magdy Bayoumi, Fellow, IEEE, "Efficient Epileptic Seizure Prediction based on Deep Learning", IEEE Transactions on Biomedical Circuits and Systems, 1932-4545 (c) 2019.

[24] Tahir Ahmad and et.al,"Detection of Epilepsy from EEG Signal during Seizure Using Heuristic Algorithm of Fixed-Point Iterations", Research Journal of Applied Sciences, Engineering and Technology 4(19): 3584-3587, 2012 ISSN: 2040-7467

[25] ALI YADOLLAHPOUR and et.al, "Seizure Prediction Methods: A Review of the Current Predicting Techniques", Journal of Biomedical & Pharmacology Vol. 7(1), 153-162, (2014)

[26] Sun-Hee Kim and et.al, "Coercively Adjusted Auto Regression Model for Forecasting in Epilepsy EEG" Hindawi Publishing Corporation Computational and Mathematical Methods in Medicine Volume 2013, Article ID 545613, 12 pages http://dx.doi.org/10.1155/2013/545613

[27] Khansa Rasheed and et.al,"Machine Learning for Predicting Epileptic Seizures Using EEG Signals: A Review" 4 Feb-2020, International Journal of Biomedical Science, Vol:1, Pages 12.

[28] Hari Prasad," A novel method for seizure prediction based on autoregressive modelling and a real-time error correction algorithm", International Journal of Applied Engineering Research Volume 10, Issue 10, 2015, Pages 25475-25492

[29] SYED MUHAMMAD USMAN and et.al, "Epileptic Seizures Prediction Using Deep Learning Techniques", February 19, 2020, DOI:10.1109/ACCESS.2020.2976866, Pages 10

[30] Reza Abbasi and et.al," The Deep Tune framework for modelling and characterizing neurons

in visual cortex area V4", doi: https://doi.org/10.1101/465534bioRxiv, Nov 8 2018

[31] Deepashri Agrawal, "Prosody Perception in Cochlear Implant Users: EEG evidence,", Thesis Submitted in partial fulfilment of the requirements for the degree DOCTOR OF PHILOSOPHY (PhD) awarded by the University of Veterinary Medicine Hannover 2012.

[32] David E. Snyder and et.al," The Statistics of a Practical Seizure Warning System Neural Eng. 2008 December; 5(4): 392–401. doi:10.1088/1741-2560/5/4/004

[33] Jouko Lampinen and et.al," Discrete Neural Signatures of Basic Emotions", Cerebral Cortex Advance Access published April 29, 2015, doi: 10.1093/cercor/bhv086

[34] Wei Liu, Jie-Lin Qiu and et.al, "Multimodal Emotion Recognition Using Deep Canonical Correlation Analysis",Aug-2019,Pages-12,arXiv-1908:5349v1

[35] Yuya Moroto and et.al,"Tensor-Based Emotional Category Classification via Visual Attention-Based Heterogeneous CNN Feature Fusion",10 April 2020, Pages-1-15, Open Access Sensor Journal

[36] Xun Wu Member, IEEE,"Investigating EEG-Based Functional Connectivity Patterns for Multimodal Emotion Recognition",4-Apr 2020 , arXiv:2004.01973v1,Pages-1-15

[37] Panagiotis Tzirakis and et.al ,"End-to-End Multimodal Emotion Recognition using Deep Neural Networks", IEEE Journal of Selected Topics in Signal Processing, vol. 11, no. 8, pp. 1301–1309, 2017.

[38] TING-WEI SUN,Graduate Student Member, IEEE and et.al, "End-to-End Speech Emotion Recognition With Gender Information ",IEEE Explore Open Access ,August 18, 2020, DOI: 10.1109/ACCESS.2020.3017462.

[39] P Bhuvaneswari and et.al," Support Vector Machine Technique for EEG Signals", International Journal of Computer Applications (0975 – 8887) Volume 63– No.13, February 2013

[40] Ali Shoeb and et.al, "Application of Machine Learning to Epileptic Seizure Detection", Proceedings of the 27 th International Conference on Machine Learning, Haifa, Israel, 2010

[41] Vidyaratne, L.S., Iftekharuddin, K.M. Real-Time Epileptic Seizure Detection Using EEG (2017) IEEE Transactions on Neural Systems and Rehabilitation Engineering, 25 (11), art. no. 7911296, pp. 2146-2156

[42] Alotaiby, T.N., Alshebeili, S.A., Alshawi, T., Ahmad, I., Abd El-Samie, F.E.,"EEG seizure detection and prediction algorithms: a survey (2014)", Eurasip Journal on Advances in Signal Processing, 2014 (1), art. no. 183, pp. 1-21.

[43] Yildirim, O and et.al, " A deep convolutional neural network model for automated identification of abnormal EEG signals", NEURAL COMPUTING & APPLICATIONS,

Volume: 32 Issue: 20 Pages: 15857-15868 DOI: 10.1007/s00521-018-3889-z Published: OCT 2020

[44] Zhang, Q., Ding, J., Kong, W., Liu, Y., Wang, Q., Jiang, T., "Epilepsy prediction through optimized multidimensional sample entropy and Bi-LSTM (2021) ", Biomedical Signal Processing and Control, 64, art. no. 102293.

[45] Sharma, M.K., Ray, K., Yupapin, P., Kaiser, M.S., Ong, C.T., Ali, J. "Comparative analysis of different classifiers on eeg signals for predicting epileptic seizure (2021)", Advances in Intelligent Systems and Computing, 1309, pp. 193-204.

[46] Mohanty, N.P., Dash, S.S., Sobhan, S., Swarnkar, T.,"Prediction of Depression Using EEG: A Comparative Study (2021)", Advances in Intelligent Systems and Computing, 1199, pp. 3-11.

[47] Bomela, W., Wang, S., Chou, C.-A., Li, J.-S., "Real time Inference and detection of disruptive EEG Networks for Epileptic Seizures (2020)", Scientific Reports, 10 (1), art. no. 8653.

[48] Romney, A.,Manian,V., "Comparison of frontal-temporal channels in epilepsy seizure prediction based on eemd-relieff and DNN (2020)", Computers, 9 (4), art. no. 78, pp. 1-14.

[49] Goldstein, L., Margiotta, M., Guina, M.L., Sperling, M.R., Nei, M, "Long-term video-EEG monitoring and interictal epileptiform abnormalities (2020) Epilepsy and Behavior", 113, art. no. 107523.

[50] Hamavar, R., Asl, B.M., "Seizure onset detection based on detection of changes in brain activity quantified by evolutionary game theory model (2021)", Computer Methods and Programs in Biomedicine, 199, art. no. 105899

[51] Satyender, Dhull, S.K., Singh, K.K." A Review on Automatic Epilepsy Detection from EEG Signals (2021)" Lecture Notes in Electrical Engineering, 668, pp. 1441-1454.

[52] Sreekumar, A., Sasidhar Reddy, A.N., Udaya Ravikanth, D., Chaitanya Chowdary, M., Nithin, G., Sathidevi, P.S.," Machine Learning Techniques for epileptic seizure detection -2021", Lecture Notes in Electrical Engineering, 668, pp. 919-926.

[53] Verma, A., Janghel, R.R. Epileptic seizure detection using deep recurrent neural networks in eeg signals (2021) Lecture Notes in Bioengineering, pp. 189-198.

[54] Singh, G., Kaur, M., Singh, B.,"Detection of Epileptic Seizure EEG Signal Using Multiscale Entropies and Complete Ensemble Empirical Mode Decomposition (2021)", Wireless Personal Communications, 116 (1), pp. 845-864.

[55] Siddiqui, M.K., Morales-Menendez, R., Huang, X., Hussain, N. "A review of epileptic seizure detection using machine learning classifiers (2020)", Brain Informatics, 7 (1), art. no. 5,.

[56] Siddiqui, M.K., Huang, X., Morales-Menendez, R., Hussain, N., Khatoon, K.," Machine

learning based novel cost-sensitive seizure detection classifier for imbalanced EEG data sets (2020)", International Journal on Interactive Design and Manufacturing, 14 (4), pp. 1491-1509.

[57] Mera-Gaona, M and et.al., "Epileptic spikes detector in pediatric EEG based on matched filters and neural networks (2020)", Brain Informatics, 7 (1), art. no. 4.

[58] Cao, J., Zhu, J., Hu, W., Kummert, A.,"Epileptic signal classification with deep eeg features by stacked cnns (2020)", IEEE Transactions on Cognitive and Developmental Systems, 12 (4), art. no. 8807291.

[59] Goldstein, L., Margiotta, M., Guina, M.L., Sperling, M.R., Nei, M.," Long-term video-EEG monitoring and interictal epileptiform abnormalities (2020)", Epilepsy and Behavior, 113, art. no. 107523,

[60] Ryvlin, P., Beniczky, S," Seizure detection and mobile health devices in epilepsy: Recent developments and future perspectives (2020)", Epilepsia, 61 (S1), pp. S1-S2.

[61] Tio, E., Culler, G.W., Bachman, E.M., "Schuele, S. Ictal central apneas in temporal lobe epilepsies (2020) Epilepsy and Behavior", 112, art. no. 107434.

[62] Jeppesen, J., Fuglsang-Frederiksen, A., Johansen, P., Christensen, J., Wüstenhagen, S., Tankisi, H., Qerama, E., Beniczky, S., "Seizure detection using heart rate variability: A prospective validation study (2020)", Epilepsia, 61 (S1), pp. S41-S46

[63] Mittlesteadt, J., Bambach, S., Dawes, A and et.al. ,"Evaluation of an activity tracker to detect seizures using machine learning algorithms (2020)", Journal of Child Neurology, 35 (13), pp. 873-878

[64] Hou, Q., Liu, Y., Liu, J., Sun, S.," Epilepsy Detection Using Random Forest Classification Based on Locally Linear Embedding Algorithm (2020)", 2020 5th International Conference on Control, Robotics and Cybernetics, CRC 2020, art. no. 9253455, pp. 202-206.

[65] Takahashi, H., Emami, A., Shinozaki, T., Kunii, N., Matsuo, T., Kawai, K., "Convolutional neural network with autoencoder-assisted multiclass labelling for seizure detection based on scalp electroencephalography (2020)", Computers in Biology and Medicine, 125, art. no. 104016.

[66] Tibdewal, M.N., There, A.S., Mahadevappa, M., Ray, A.K., Malokar, M. Performance analysis of power and power variance for classification, detection and localization of epileptic multi-channel EEG (2020) Microsystem Technologies, 26 (10), pp. 3129-3142.

[67] Maidana Capitán, M., Cámpora, N., Sigvard, C.S., Kochen, S., Samengo, I. Time- and frequency-resolved covariance analysis for detection and characterization of seizures from intracranial EEG recordings (2020) Biological Cybernetics, 114 (4-5), pp. 461-471.

[68] Chahid, A., Albalawi, F and et.al., "PWM: Feature extraction method for epileptic spike classification (2020)", IEEE Journal of Biomedical and Health Informatics, 24 (10), art. no. 8986627, pp. 2814-2824

[69] Grishchenko, A.A., Sysoeva, M.V., Medvedeva, T.M., van Rijn, C.M., Bezruchko, B.P., Sysoev, I.V. Comparison of approaches to directed connectivity detection in application to spike-wave discharge study (2020) Cybernetics and Physics, 9 (2), pp. 86-97

[70] Fathima, T., Rahna, P., Gaffoor, T. Wavelet based detection of epileptic seizures using scalp EEG (2020) International Conference on Futuristic Technologies in Control Systems and Renewable Energy, ICFCR 2020, art. no. 9249989

[71] Mittlesteadt, J., Bambach, S., Dawes, A and et.al. ,"Evaluation of an activity tracker to detect seizures using machine learning algorithms (2020)", Journal of Child Neurology, 35 (13), pp. 873-878

[72] Siddiqui, M.K., Morales-Menendez, R., Huang, X., Hussain, N. "A review of epileptic seizure detection using machine learning classifiers (2020)", Brain Informatics, 7 (1), art. no. 5.

[73] Goldstein, L., Margiotta, M., Guina, M.L., Sperling, M.R., Nei, M, "Long-term video-EEG monitoring and interictal epileptiform abnormalities (2020) Epilepsy and Behavior", 113, art. no. 107523.

[74] Sreekumar, A., Sasidhar Reddy, A.N., Udaya Ravikanth, D., Chaitanya Chowdary, M., Nithin, G., Sathidevi, P.S.," Machine Learning Techniques for epileptic seizure detection -2021", Lecture Notes in Electrical Engineering, 668, pp. 919-926.

[75] Panagiotis Tzirakis and et.al,"End-to-End Multimodal Emotion Recognition using Deep Neural Networks", IEEE Journal of Selected Topics in Signal Processing, vol. 11, no. 8, pp. 1301–1309, 2017.

[76] P Bhuvaneswari and et.al," Support Vector Machine Technique for EEG Signals", International Journal of Computer Applications (0975 – 8887) Volume 63– No.13, February 2013

[77] Deepashri Agrawal, "Prosody Perception in Cochlear Implant Users: EEG evidence,", Thesis Submitted in partial fulfilment of the requirements for the degree DOCTOR OF PHILOSOPHY (PhD) awarded by the University of Veterinary Medicine Hannover 2012.

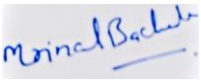
[78] Singh, G., Kaur, M., Singh, B."Detection of Epileptic Seizure EEG Signal Using Multiscale Entropies and Complete Ensemble Empirical Mode Decomposition (2021)", Wireless Personal Communications, 116 (1), pp. 845-864.

[79] Vidyaratne, L.S., Iftekharuddin, K.M. Real-Time Epileptic Seizure Detection Using EEG (2017) IEEE Transactions on Neural Systems and Rehabilitation Engineering, 25 (11), art. no. 7911296, pp. 2146-2156

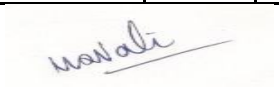
[80] Wei Liu, Jie-Lin Qiu and et.al, "Multimodal Emotion Recognition Using Deep Canonical Correlation Analysis",Aug-2019,Pages-12,arXiv-1908:5349v1

Checklist to be signed by the Scholar and the Supervisor

Sr No	Description	Yes	No
1.	The title is in Title Case	Yes	
2.	The top cover is adhering to the format given	Yes	
3.	The scholar has written his/ her name as per SCRI records	Yes	
4.	The PRN is correct as per SCRI records	Yes	
5.	The certificate is signed by scholar and supervisor if applicable	Yes	
6.	The proposal is written covering all the required headings	Yes	
7.	Figure captions are at the bottom of figures	Yes	
8.	Table captions are at the top of tables	Yes	
9.	The scholar has given references and not the bibliography	Yes	
10.	All references are cited in the text	Yes	
11.	All cited references in the text are listed at the back	Yes	
12.	The listed references are adequate (15-40 references)	Yes	
13.	The scholar has given page numbers	Yes	
14.	The title do not align to objectives		No
15.	The research proposal is 15-25 pages long	Yes	
16.	Acronyms are defined when they appear for first time in the text	Yes	
17.	The introduction is appropriately addressing the topic	Yes	
18.	The background builds up a good argument for research	Yes	
19.	The need for doing research is clearly spelt out	Yes	
20.	The literature review contains authentic references from peer reviewed journals	Yes	
21.	The literature review does not cite too old references unless Classical	Yes	
22.	The research gap is identified clearly	Yes	
23.	The research questions are appropriate	Yes	
24.	The objectives are clear and are written point wise	Yes	
25.	The hypothesis and null hypothesis is provided		No
26.	The research methodology is given in detail	Yes	
27.	The reason for choosing a particular research method is mentioned in the proposal	Yes	
28.	The research aims at addition of new knowledge	Yes	
29.	The timeframe is appropriate for the work	Yes	
30.	The document is free from spelling errors & grammatical errors.	Yes	



Signed by Research Supervisor
Dr. Mrinal R Bachute
Associate Professor, Computer Science Engineering Department



Signed by Research Scholar
Milind Ashok Natu
(PRN: 19079001058)

Symbiosis Institute of Technology,
Symbiosis International (Deemed University), Pune

Proforma-3

Undertaking from the Ph.D. student while submitting his/her research proposal to SCRI
Ref. No. _____

I, Milind Ashok Natu the undersigned, hereby declare and give an undertaking that the research proposal entitled "Brain Dysfunction analysis detection System using Deep Neural Network" under the Faculty of "Electronics and Telecommunication" has been checked for its Similarity Index for Plagiarism through an authentic "Turnitin" software tool; and that the document has been prepared by me and is my original work and free of any plagiarism. It was found that:

1.	The Similarity Index (SI) was: *(Note: SI range: 0 to 10%; if SI is >10%, then the student cannot submit his/her thesis; attachment of SI report is mandatory)*	1%
2.	The material (adopted text, tables, figures, graphs, etc.) as has been obtained from other sources, has been duly acknowledged in the thesis: *(Note: Tick √ whichever is applicable)*	Yes / No

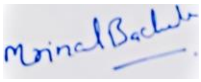
In case if any of the above-furnished information is found false at any point in time, then the University authorities can take action as deemed fit against me.

Signature, Full Name & PRN
of the Ph.D. student

Date: 11/01/2021

Place: Pune

Milind Ashok Natu
PRN-19079001078



Signature &
Name of Supervisor
Associate Professor, Electronics and
Telecommunication Engineering Department
Symbiosis Institute of Technology
Symbiosis International (Deemed University), Pune

Signature &
Name of Co-supervisor